

INVESTIGATION OF ELECTROWEAK INTERACTION THROUGH MEDIATOR

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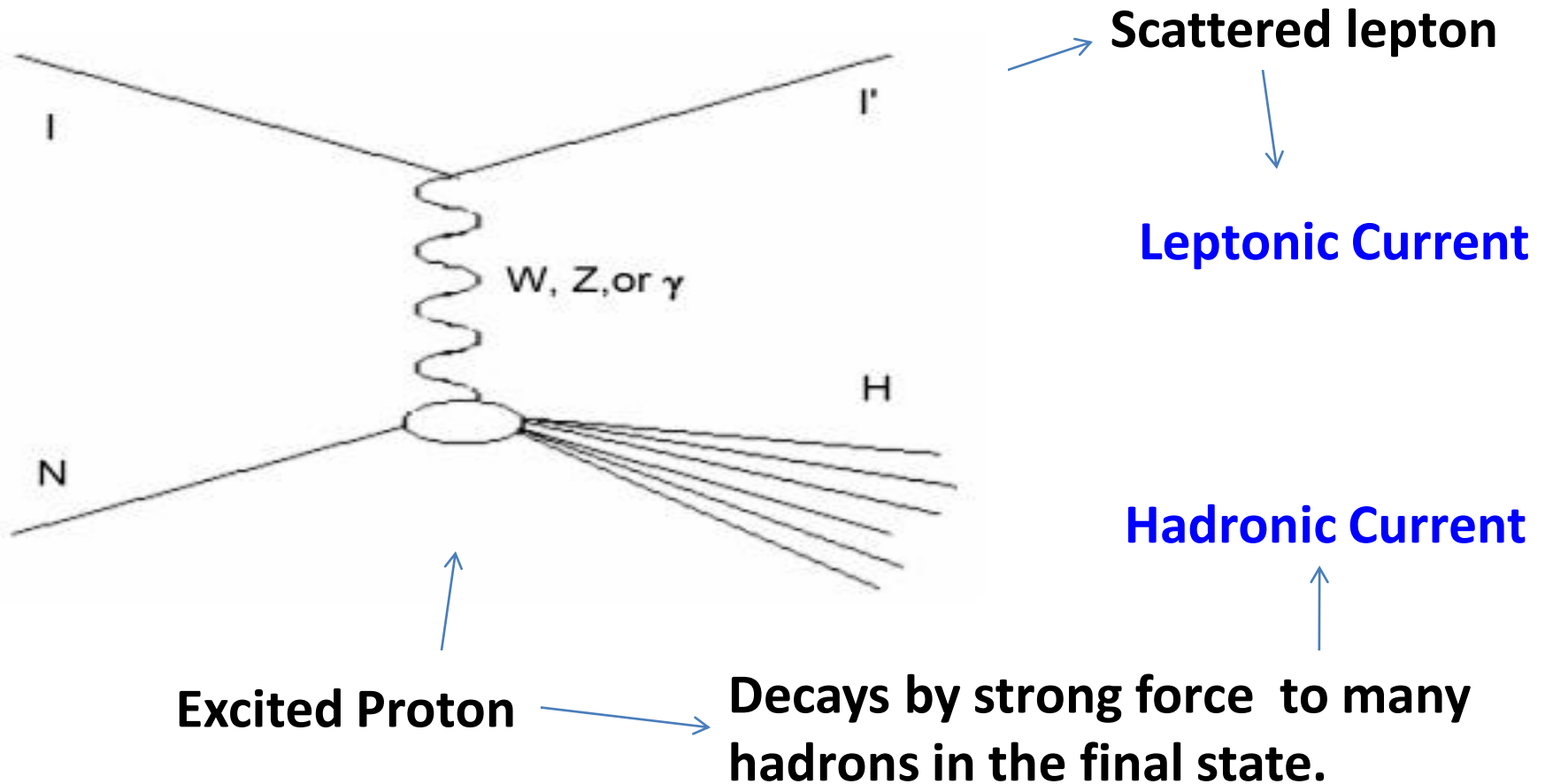
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What I did?

- At high energy, I studied the interaction of weak particle as neutrino and the interaction of electroweak particle as muon.
- By comparing the results of these interactions we can look to the features of electroweak force.

Feynman diagram

□ The last interaction can be described by Feynman diagram of two vertices.



Leptonic current # first vertex

□ The leptonic current is given by:-

$$J^\nu = (g / 2) \psi'(v') \gamma_\mu (1 - \gamma_5) \psi(v) \quad (1)$$

Wave function for
scattered neutrino

Wave function for
Incident neutrino

Weak vertex vector

γ_5 is a 4×4 matrix that defined in terms of the Dirac matrices as $\gamma_5 = i\gamma^0\gamma^1\gamma^2\gamma^3$

Wave function for incident ν ## Dirac Equation

□ We deal with particles of spin $\frac{1}{2}$ (Leptons) at high energies ($\lambda \sim 10^{-15}\text{m} \sim$ hadron radii) .

□ Relativistic Quantum Theory is described like these particles by Dirac equation: (Where: $\hbar = c = 1$)

$$i\partial\psi / \partial t = (-i\alpha \cdot \nabla + \beta m)\psi$$

□ Then the solution gives us a plane wave for the incident neutrino as:

$$\psi(r) = u(p)e^{-ik.r} \quad (2)$$

Wave function for scattered ν # Perturbation Theory#

□ The wave function for the scattered neutrino is determined by using perturbation technique as:

$$\psi'(k', r) = \left\{ \psi(k', r) + (2\pi)^{3/2} f \frac{\exp(ik'r)}{r} \right\} \quad (3)$$

scattering amplitude

$$f = \sum f_1 + f_2 + \dots$$

The sum runs over the possible orders of perturbation.

Wave function for scattered v # Perturbation Theory#

$$f = V_{fi} + \int d^3 p_n \frac{V_{fn} V_{ni}}{E - E_n^0 + i\varepsilon} + \int \int d^3 p_{n'} d^3 p_n \frac{V_{fn'} V_{n'n} V_{ni}}{(E - E_{n'}^0 + i\varepsilon)(E - E_n^0 + i\varepsilon)} + \dots$$

□ Since the scattering is due to weak field, then it is sufficient to consider only one term in previous series:

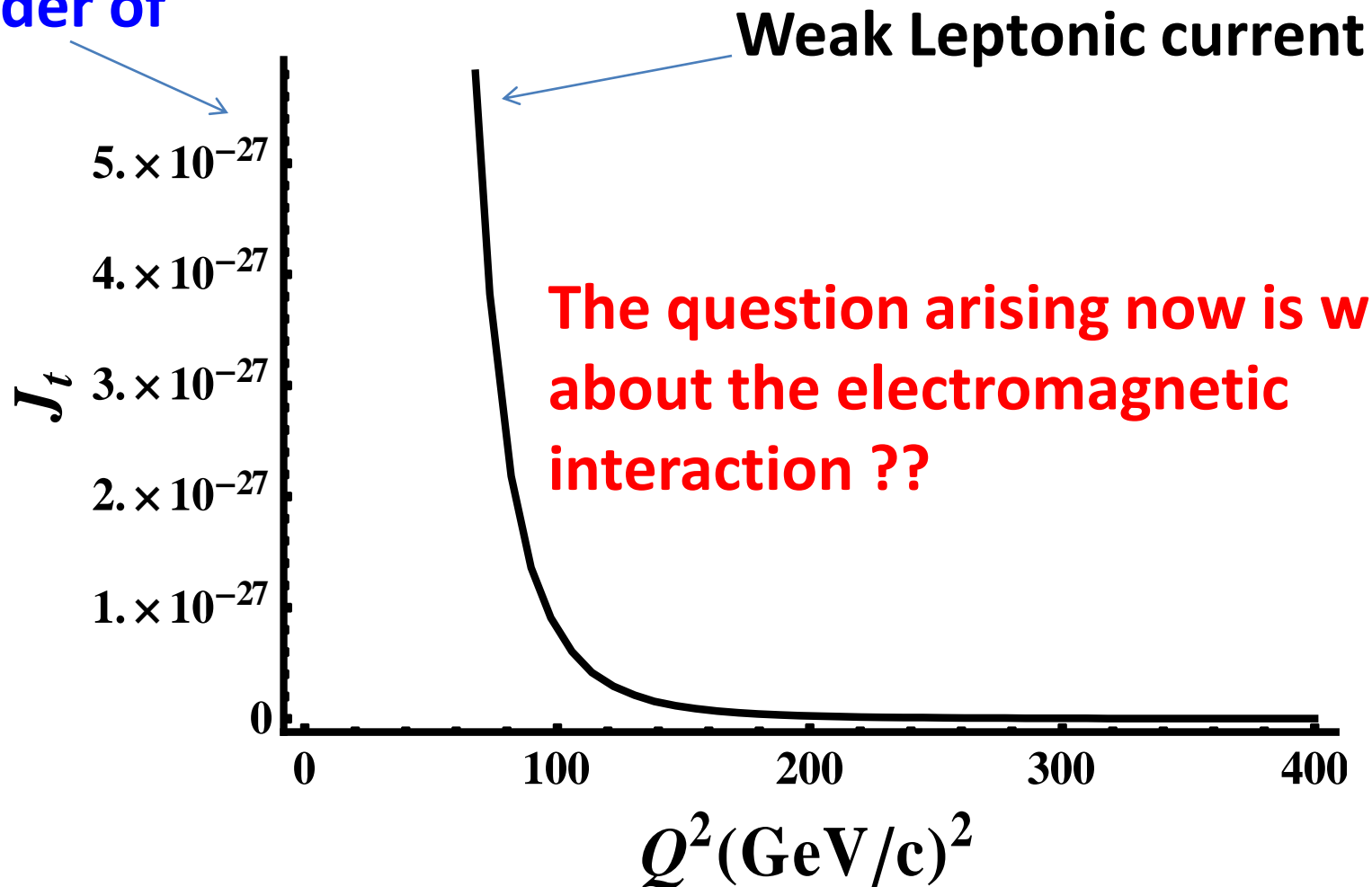
The first term is $\longrightarrow V_{fi} = \langle f | V(\vec{r}) | i \rangle$

Where the weak potential has the form:

$$V(\vec{r}) = V_0 \exp(-M_z r)$$

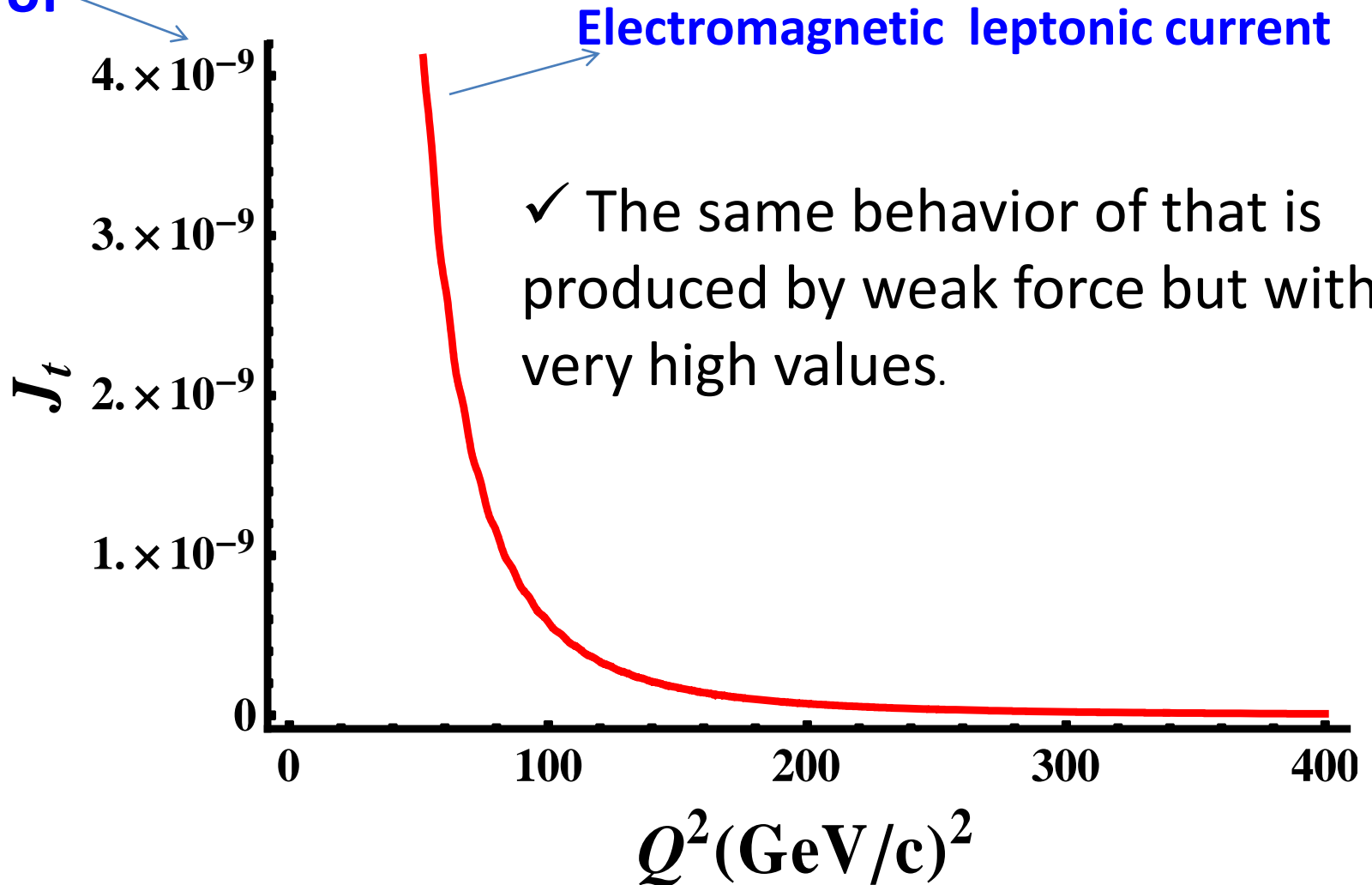
Leptonic current produced by neutrino as function of Q^2

In order of

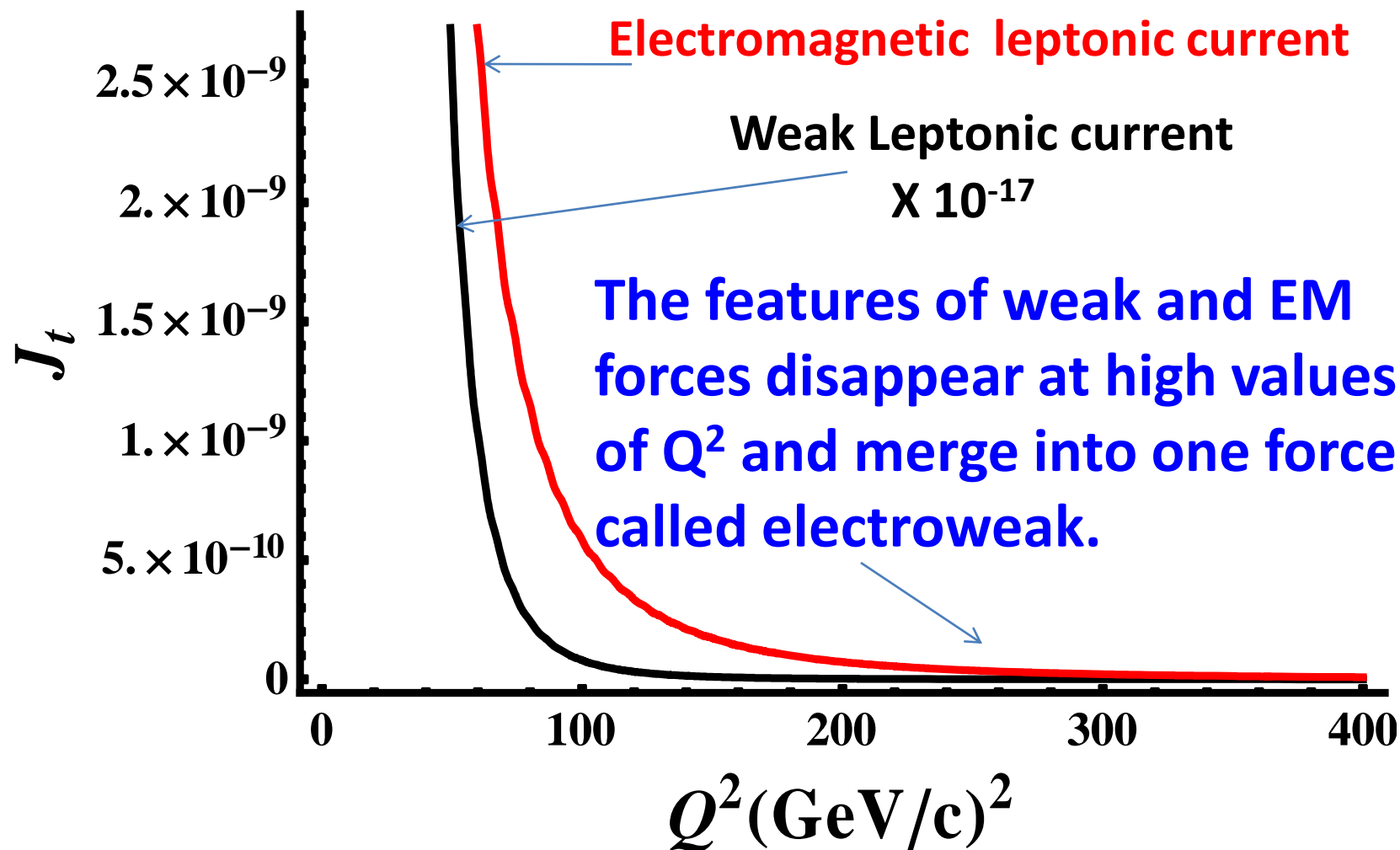


Leptonic current produced by muon as function of Q^2

In order of



Electroweak Leptonic current



Hadronic (or quark) current ## Second vertex

In general, quark current is defined as function of x (Bjorken parameter) and q^2 (the square transfer momentum) by:

$$J_q(x, q^2) = \sum \bar{u}(x, q'^2) \gamma_\mu \frac{1}{2} (1 - \gamma_5) u(x, q'^2)$$

For all valence quarks

Quark conjugate function

Vertex vector

Quark wave function

❖ It is interested to find the weak quark functions and the EM quark functions. Is there different ??

Quark wave functions or PDFs

□ The Standard Model suggests that :

➤ The **EM quark wave functions** are given as:

$$F_2^{\mu p} = \frac{4}{9}u(x) + \frac{1}{9}d(x) \qquad F_2^{\mu n} = \frac{4}{9}d(x) + \frac{1}{9}u(x)$$

➤ The **weak quark wave functions** are given as:

$$F_2^{\nu p} = 2x[d(x) + \bar{u}(x)] \qquad xF_3^{\nu p} = 2x[\bar{u}(x) - d(x)]$$

$$F_2^{\nu n} = 2x[\bar{d}(x) + u(x)] \qquad xF_3^{\nu n} = 2x[\bar{d}(x) - u(x)]$$

Structure functions

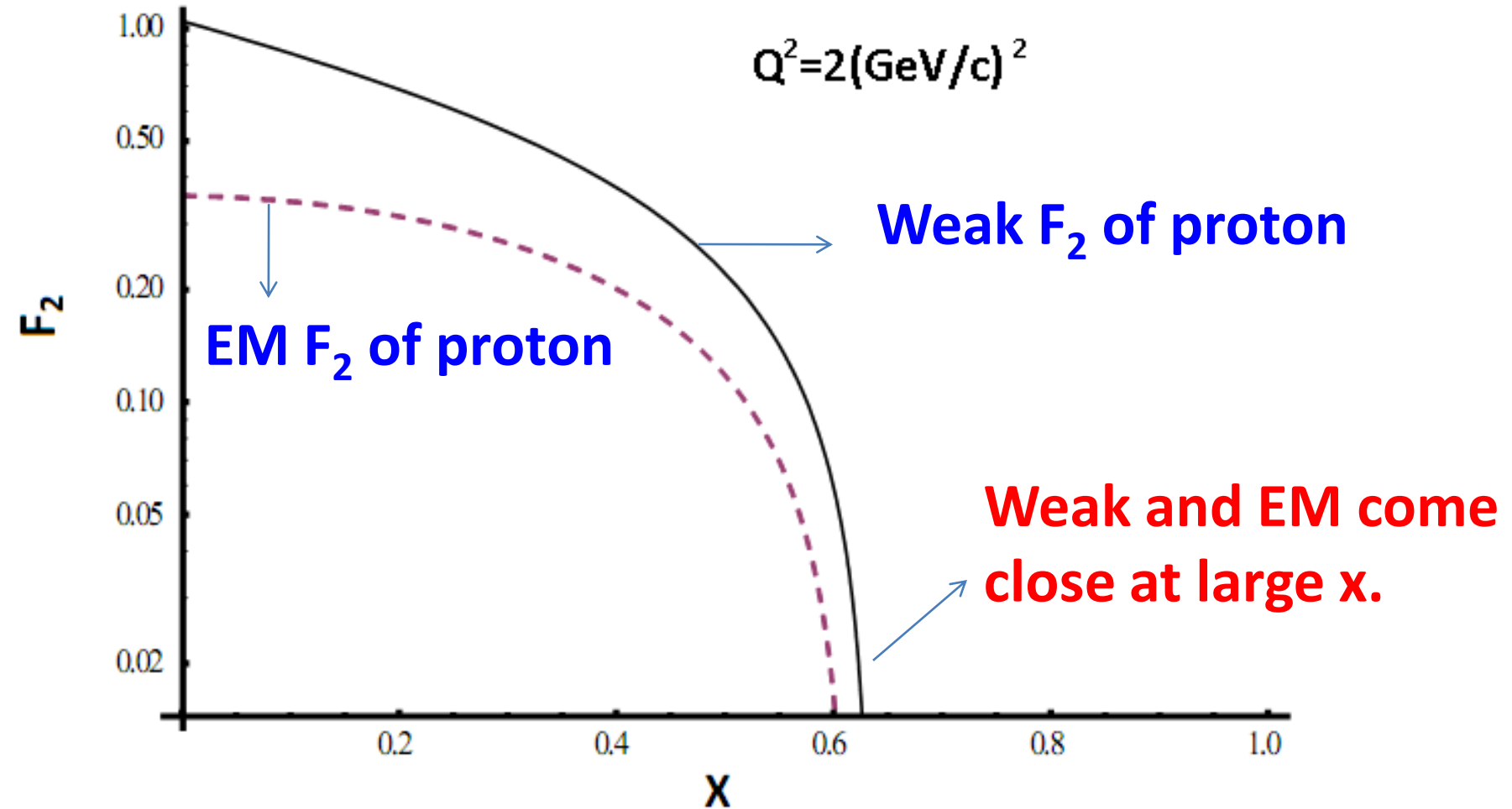
- All the needed data for muon and neutrino are collected at the same energy.
- I fitted the data to get a unique parametric form that can describe all data.

$$F_{2,3}(x, Q^2) = A[x]e^{-B[x]Q^2}$$

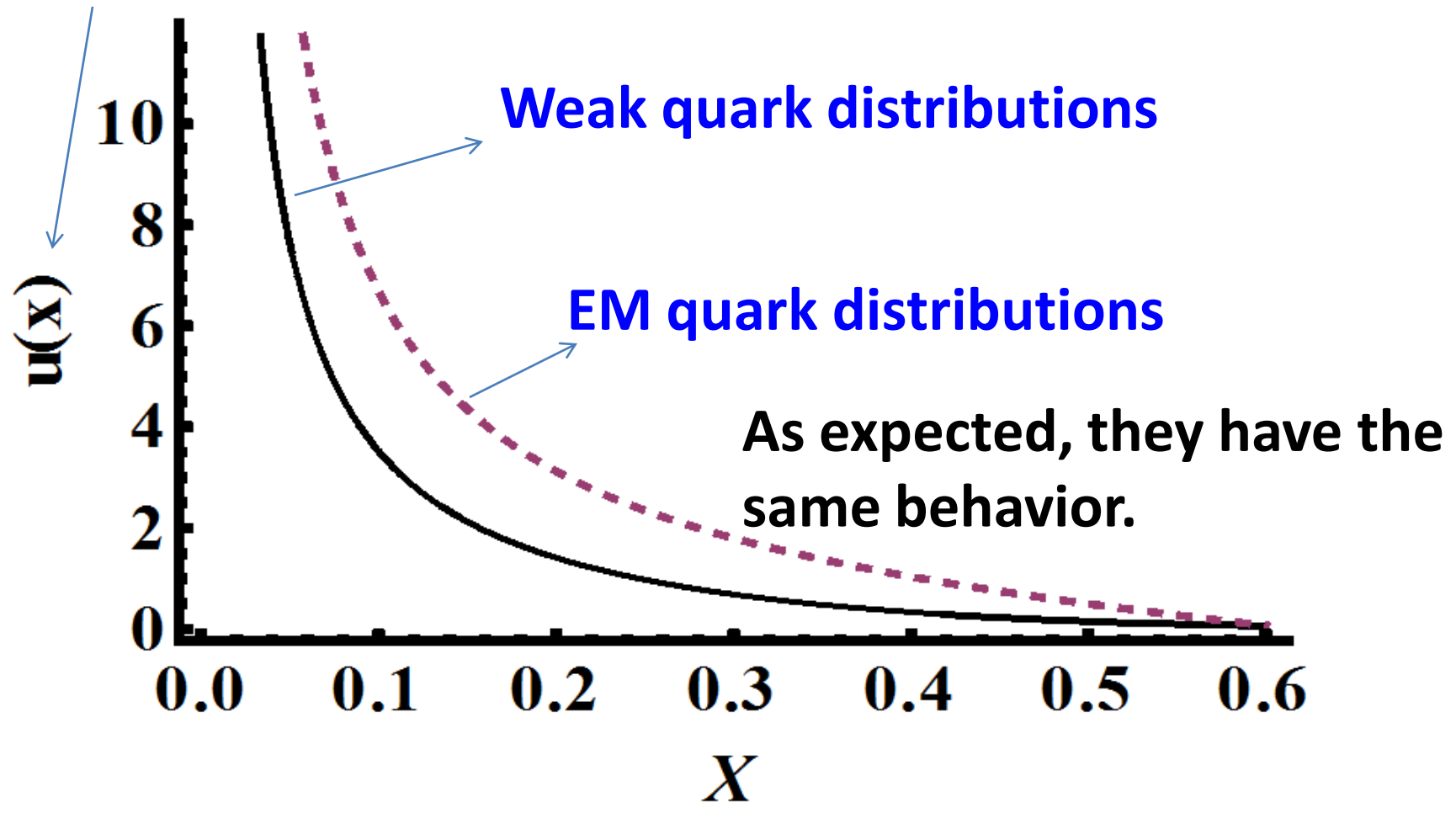
$$A[x] = a_0 + a_1x + a_2x^2$$

$$B[x] = b_0 + b_1x + b_2x^2$$

Results

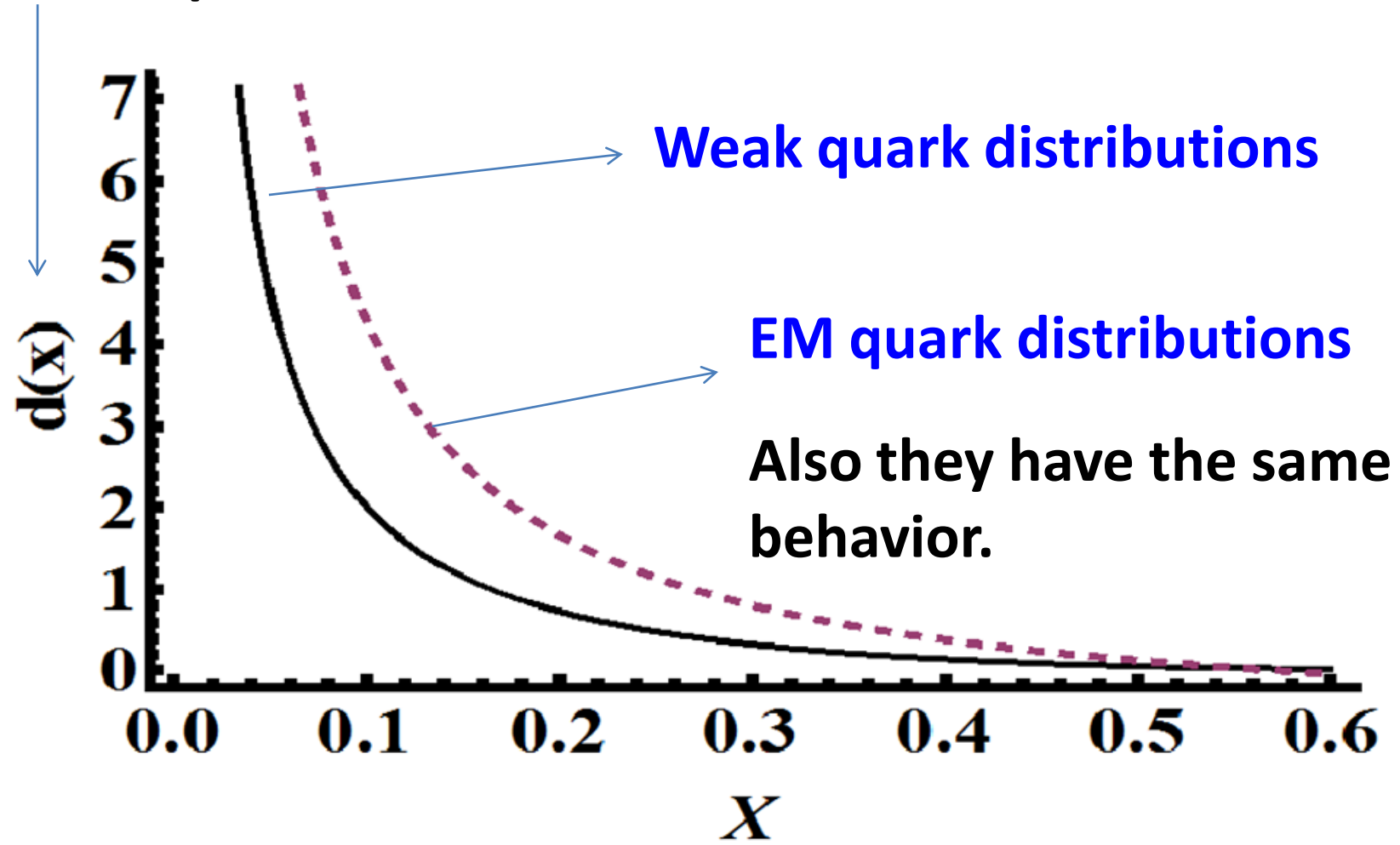


Up quark wave functions

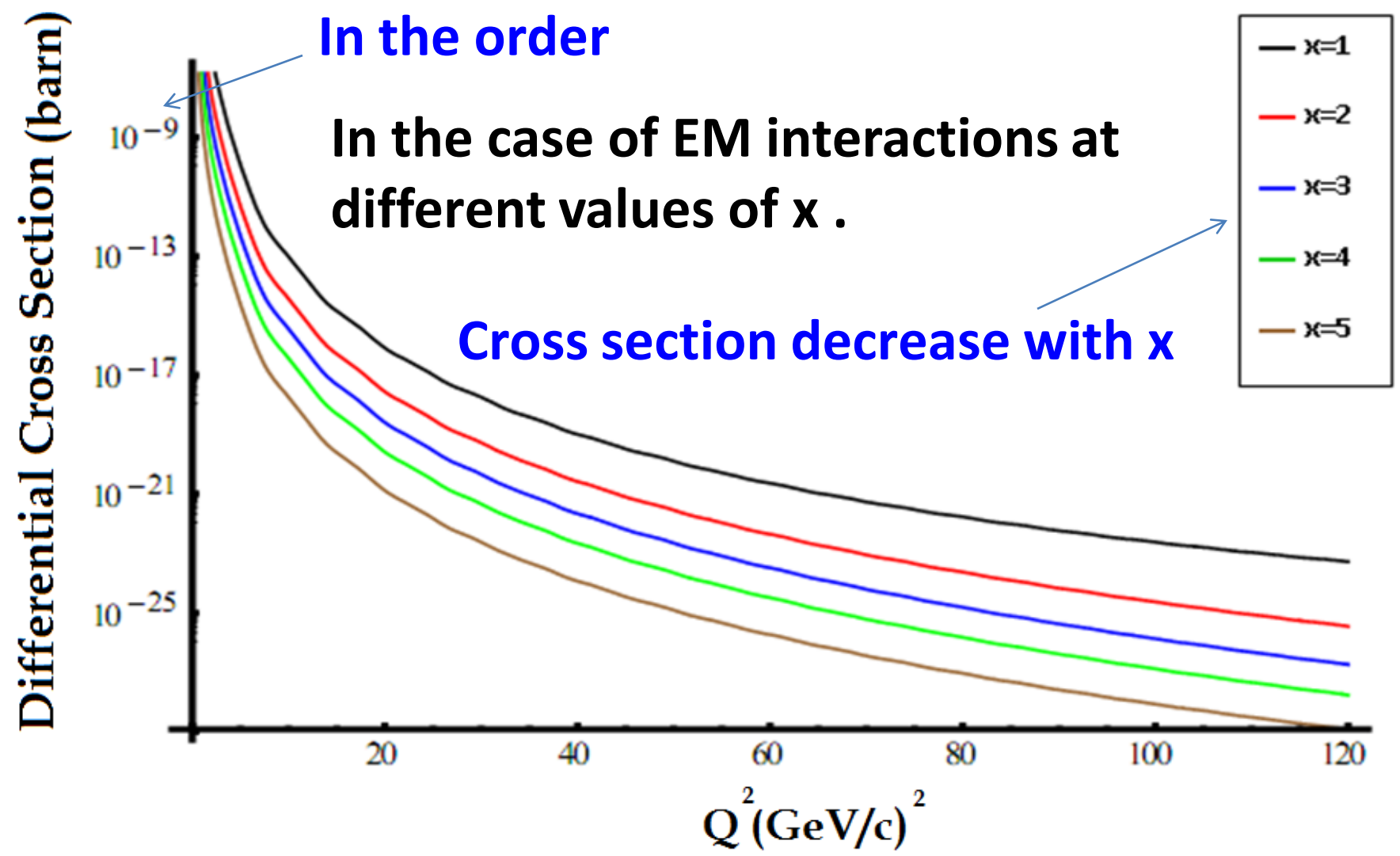


Results

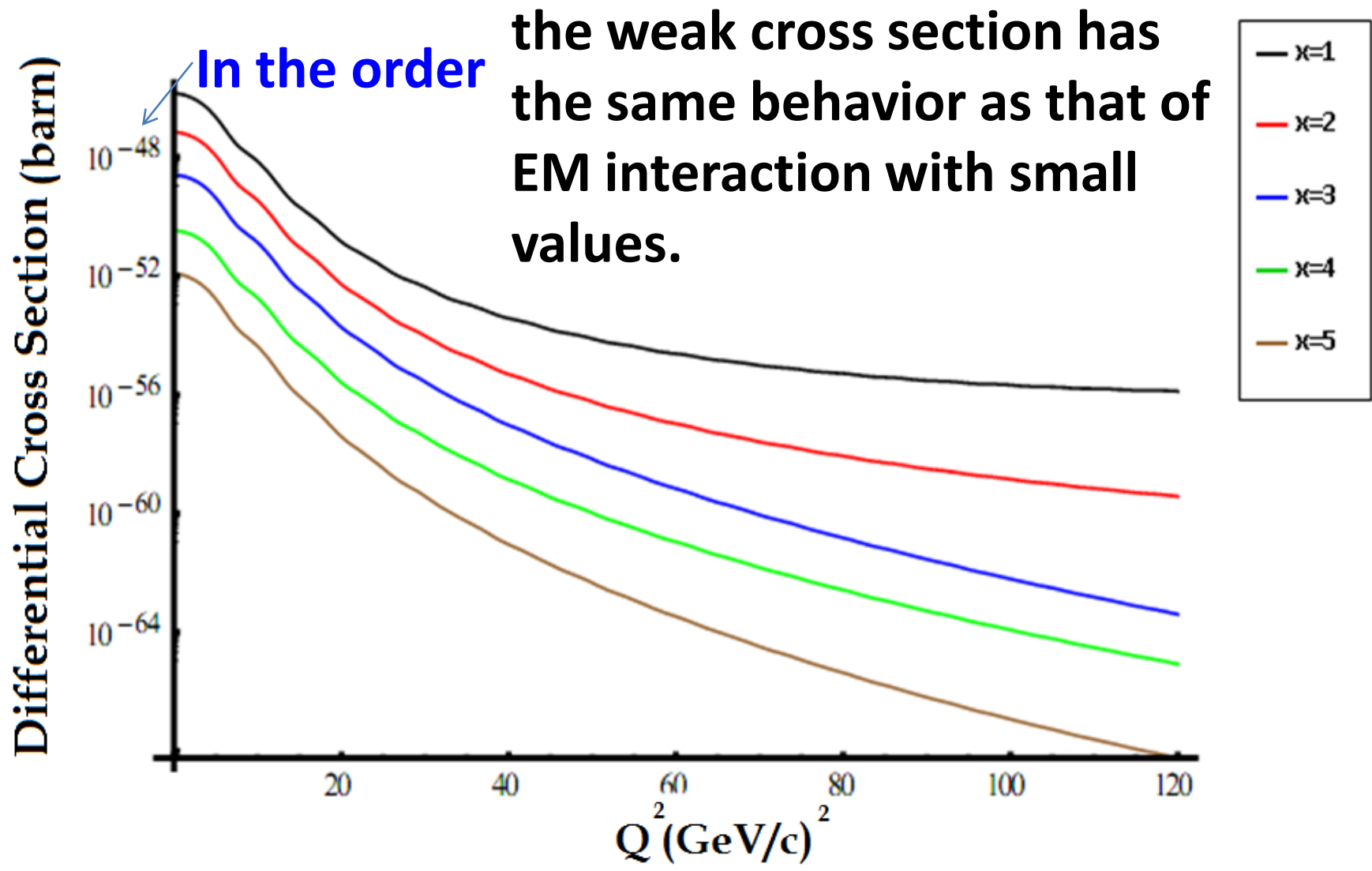
Down quark wave function



Results



Results



*Any
Question?*

THANK YOU